# Wetland Surface Flow and Stream Crossings

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There are three caveats that I want to lay out before I get into this presentation. Number one is to apologize to the entire industry, which has no counterpart making a presentation here - if there is a bias to my presentation, I apologize. Second, although I've been involved in many of the more controversial cross-drainage discussions and permitting decisions on the North Slope, my primary responsibilities have been on the statewide-level, and more recently working with BC, the Pacific Northwest, and California in trying to develop culvert design guidelines. Finally, most of this talk is going to focus on stream crossings of fish-bearing waters, and to a lesser extent on basic surface runoff, which is more directly the responsibility of DEC and the Army Corps of Engineers. That said, what I'd like to do is run through some of the major impacts associated with cross drainage structures on the North Slope, the leading causes of failure as ascertained over the years, the lessons that we've learned over the last 30 years, and some of the future directions that I think we are probably going to be moving toward.

Obviously, culverts can create barriers to fish passage. A prime example in this picture is a culvert battery that was installed with either a combination of being undersized and/or a failure to provide sufficient outlet scour protection. As you can see, what has happened is a degradation of the stream back to about here, it has dropped the downstream thalweg elevation, the outlet has become perched, and outwash gravel has formed a berm right downstream of the culverts. At low water, water percolates or french drains through these berms, and they are barriers to fish. The second thing that can happen, as you may note here in the picture, is that is often is standard practice to block the inlet and outlet to these pipes with plywood or some other structure during the winter months to try to keep snowdrifts out of them. This is done so they do not ice up, and are free to flow during breakup. Sometimes the plywood barriers are not removed prior to breakup. In those cases, the plywood becomes the barrier.

Improper design and installation can also cause upstream ponding of the surface flow if it is inadequately sized. This picture is an example of a pipe crossing an area where water was impounded upstream from a culvert battery during the springtime.

Improper design and installation can also cause changes in channel morphology, as the difference both immediately upstream and further upstream of the culvert in this photo depict.

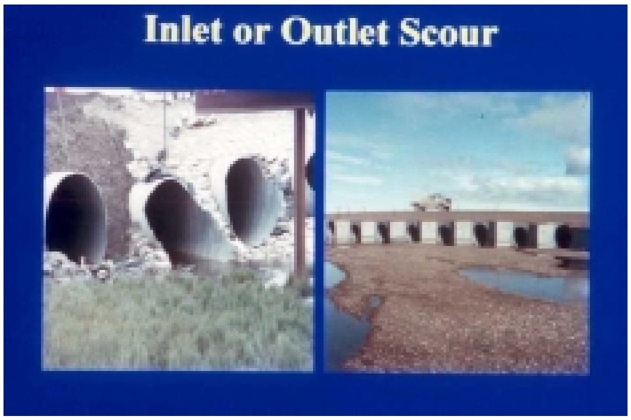
These problems can cause significant changes in maintenance costs.  One typical thing is that any flooding can cause erosion of the protection that you have put on the culvert battery.

This requires annual maintenance.  Improper cleaning activities in springtime can cause damage.   As you can see, the culverts have been bent and twisted here.  If there is sufficient damage, these culverts will have to be replaced.  Another thing that is associated with maintenance is the need for ice protection.  You don't have a free flood plain channel anymore, and some degree of ice protection is going to be needed to protect the structure and the roads from ice.

This increases life-cycle costs, and can lead to road failures and operational downtime.

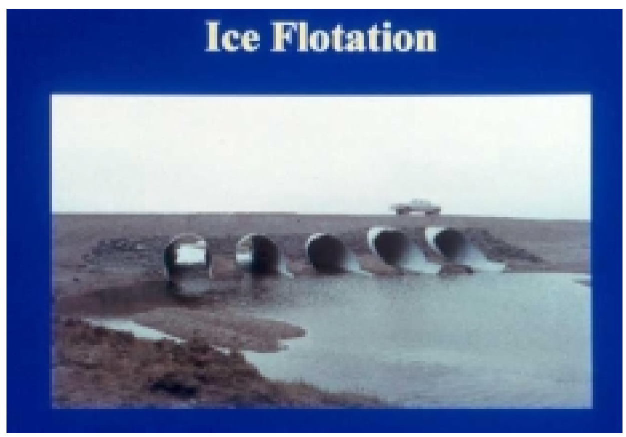
So what causes structural failures? The most obvious causes on the North Slope is under-sizing of the structure for the basin hydrology. One of the most difficult things to do on the Slope is to try to determine what the drainage area is.  It is flat, with very little relief, little structure, and many, many wetland bogs. What exactly is the drainage area? You can't ascertain it on the map, and it's hard to ascertain in the field.  Mistakes here in the design and in the sizing can cause significant problems down the road in terms of maintenance blowout.  So at best you're going to have to figure it by guesswork, and if you are going to have to guess, it is better to err on the safe side and use a bigger culvert than you think is required.

A second factor is incorrect location of the stream channel during winter construction. Because of off-road equipment transport restrictions, most of the new development occurs during wintertime operation. Trying to find channels in the wintertime in low spots and depressions when snowpack is drifting is at best an imprecise activity. How would you know where the channel is? The only way around this is to do summer staking, and to go back and install it at the same location. You're not going to find it otherwise.




Inlet or outlet scour is a typical cause of structural failure. And again this is caused by using culverts of inadequate size. Ways tried in the past to prevent scour have included sandbagging and use of scour nets. These may work for a short period of time, but inevitably you will get degradation of the fabric, and you may get ice ripping the fabric. Eventually, it will need to be replaced. The most successful technique that we have observed are the metal headwall structures that you see If this were a small to medium size drainage, these would be the most effective.

Ice flotation is another cause of structural failure. This occurs when water depth either increases dramatically on the inlet side, or ice depth increases on the inlet side. Because of the differential pressures created, this can cause an upward bending of the end of the pipe. One of the ways that this can be prevented if it is a small, non-fish bearing drainage is to use rigid, steel-wall pipes. There is no evidence of ice damage to steel-wall pipes. You can also miter the inlet, provide a vertical headwall, or you can counteract the lifting force by attaching the culvert to a concrete weight. Here is an example of a mitered inlet that helps to counteract some of those lifting forces.



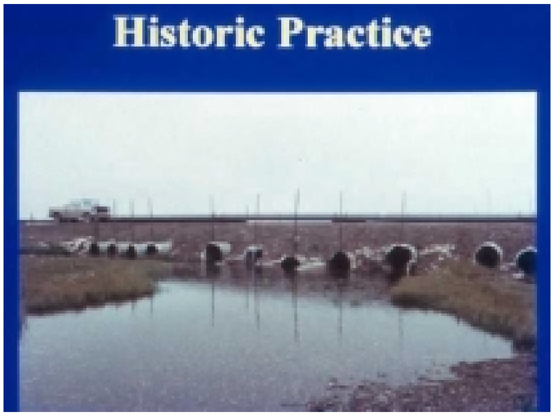

And finally, geo-technical and thaw settlement can be a major problem. Most of these soils are ice-rich permafrost, and as I indicated, a lot of the construction occurs during the wintertime. One of the things that is clear is that to avoid adverse settlement you're either going to have to maintain the permafrost in the frozen condition, or you're going to have to replace it with thaw-stable bedding material beneath the culvert, or a combination of both. This is what is typically happening now.

So, are we starting from scratch? No. Fortunately, what we have learned over the past 30 years has been put together into a design manual. This is one that was put together by G.N. McDonald in 1994 through a contract with BP Exploration, and under a DEC grant. It pretty much summarizes the state of knowledge in terms of how to calculate discharges, and the hydrology of most of these small coastal plain streams. This document is in a large part built on a companion document that was done earlier by Fish and Game, the University of Alaska-Fairbanks, and the Alaska Department of Transportation and Public Facilities that came out in 1991. This is a new approach to fish passage through cross drainage structure design that instead of just looking at velocities, integrates the forces of velocity, which is profile drag, with gradient forces, and virtual mass forces, to take a look at the combined impact of all of these forces on fish.

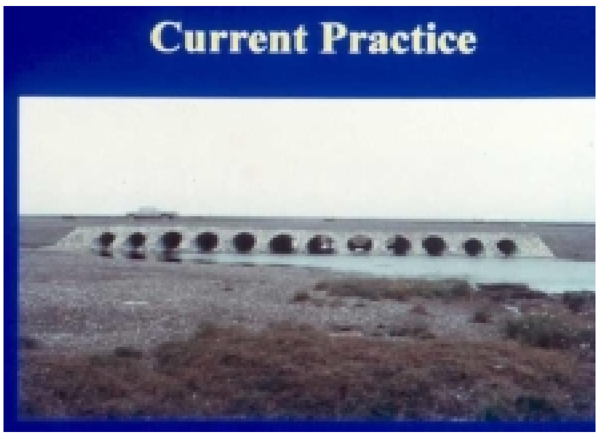
Where are we headed from here? The U.S. Forest Service has issued contracts to integrate the ADF&G/UAF/ADOT&PF design manual with the new fish crossing design manual they are developing. This means that the power/energy type concept that we have in this manual will be integrated with their more traditional velocity approach for designing of fish passage. Traditional engineering hydrological analysis tools like the Federal Highway Administration's HY-8 also will be integrated into the new computer software to provide a more complete package for evaluating culverts for fish passage. This is due out later this year. So I think that this is an exciting thing, the combination of these two documents into what is pretty much a stand-alone document and design software for most of these drainages.

So what have we learned from all of this? One of the things we have learned is that early coordination with resource agencies is critical. Many of the pipes that initially went into the oil field complex in the 70s went into streams that hadn't been surveyed. In some cases permits weren't required. Many of those pipes had to be retrofitted later to allow fish to pass through the drainages. For proposed new operations, we would like to know the plans in advance, so that we or a contractor have an opportunity to get out into the field to do an advance identification to determine what the fish passage needs are, what species are present, what time of the year they are using the pipe. Obviously whenever possible, final design should avoid fish spawning and over wintering habitat. Again early consultation allows us to make that determination and make changes in alignment when it is still possible to do so.

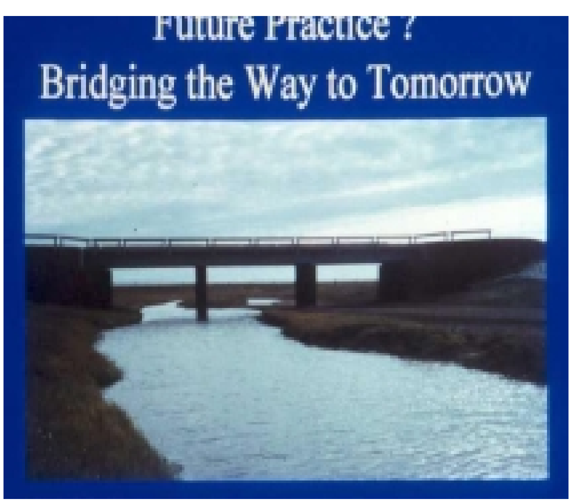
One of the things that I really want to encourage at this point is that for the medium to larger fish-bearing streams, history has shown us that culvert batteries are probably not the way to go. As the oil field has developed and matured, it has become obvious that the transportation infrastructure is there to stay. So I think that the lesson to be learned is that we need to start thinking about not only the up-front costs for a specific project, but the life cycle costs as well. What is it costing us to do the annual maintenance? What is it costing us to replace pipes? What is it costing us when we have road failures in terms of down time? And what are the tradeoffs of culverts versus bridging the structures, particularly for the larger streams? When the North Slope oil and gas fields were young, and new fields had yet to be discovered and developed, there was a clear desire to minimize up front costs. However, at this juncture, after 30 years of development and with new fields opening, it is clear that the future looks pretty bright for quite some time to come. With a longer service life that increases life-cycle maintenance costs, my advice is to focus on bridges as the preferred alternative.




So to wrap it up, in the 70s this picture depicts the state-of-art - lots and lots of small culverts and major culvert batteries.




Current practices use more refined batteries, larger pipes, more sophisticated scour protection.




In the future – perhaps our next challenge, is more bridging.

I thank you.